

The Social Web of Things (SWoT) - Structuring an Integrated Social Network for Human, Things and Services

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Abstract—In recent years, the development of IOT (Internet of Things) technology has given people many ways to obtain information through various types of physical devices. In parallel with that trend, people rely more on context-aware service and devices in many aspects, such as health care and elderly home care. However, traditional sensors are typically locked into closed systems, which hinder the access to such sensors that can be available in other information systems. Establishing free communication between human and physical things will help build a network with hybrid intelligence and amazing services. In order to share information and enable the communication between both physical devices and human, we proposed a SWoT (Social Web of Thing) framework in this paper that establishes social networking between embedded devices, services and human. Through the supernetwork approach, we discussed the service discovery in the SWoT system with heterogeneous social relations. At last, we introduced the MagicHome prototype of SWoT.

Index Terms—Internet of things, Social network, Semantic web, Service discovery

I. INTRODUCTION

In the current Internet of Things industry, things are still restricted on incompatible islands by dedicated software, and more importantly, by proprietary interface. There have been quite a number of independent researches that investigated the potentialities of integrating social network concepts into Internet of Things [12-14], which are named Social Internet of Things (SIoT). The barriers among different IoT systems still exist, the social interaction as well as information exchange still lack of universal protocols. This situation makes the sharing of data and collaboration between systems quite difficult.

Nowadays, Web protocols are mature enough to enable atomic device service and data identification, as well as provide standardized interface and low-barrier of development. Thus, WoT (Web of Things) [1,2,3] for smart things interaction on application layer through web technologies on top of the network connected by IoT is proposed. The smart things in WoT could be easily accessed or controlled by users through APIs (Application Program

Interface) as web servers, and be able to create new service processes.

In this paper, we proposed the framework of Social Web of Things (SWoT) based on supernetwork concept. In our framework, SWoT is an integrated social network and established among human, things and services so that the inhomogeneity of entities can be ignored. Moreover, the interactions across systems are allowed since the universal Web API. In such ecosystem, the issues like sharing, discovery, trustworthiness and interaction could be achieved on application layer by using social network techniques.

As shown in Figure 1, SWoT becomes an open platform for smart devices and services to publish and access data, and to communicate with human as well as others. Smart devices/services could connect directly to SWoT platform through uniform web API. For devices/services with limited capabilities, middleware acts as a broker to provide web API. Human and the third party platform could also communicate with physical world through applications with web API. To make a friendly interaction between human and things, communication middleware on the platform layer is needed. By this middleware, things can receive and transform human request in a machine-readable format. Also, things can publish their outputs in well-understood human language on the web, thus making them accessible and usable on a large scale under controlled access. From the discussed above, we

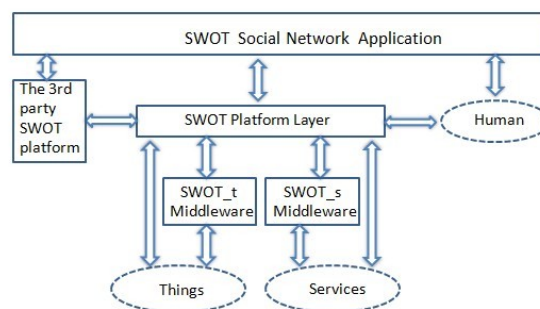


Figure 1. The Concept of Social Web of Things

conclude the benefits of supernetwork based SWoT as following:

Manuscript received June 17, 2013; revised January 2, 2012; accepted April 16, 2012. © 2005 IEEE.

This work was supported by the State Key Program of China (GrantNo.2012ZX03005008).

(1) Provide a platform with open Web APIs, standard interaction protocols, and unified resource identification, which could integrate entities (human, devices and services) in different domains. On the SWoT platform, user could share their devices and/or services through social propagation mode. Meanwhile, the platform enables cooperation and resource discovery by social relationships.

(2) Enable intelligent interaction between things and services without the participant of human. In the SWoT, things and services could establish social links, as well as the ability of reasoning and decision-making automatically or semi-automatically by machine learning and other data mining methods.

(3) To make things and services understand each other and make machine-made raw data understandable by human (user-friendly), SWoT enables structural raw data to be translated into natural language. Also, SWoT could interpret the natural language to machine language by structuring ontology base.

(4) SWoT supports better and more convenient personalized services/applications generation than IoT. On SWoT platform, not only professional developers but every common user could be able to generate their own services via visual and interactive user interfaces. From social information sharing, users could discover various trustworthy device data/ability and services they are interested in. Also, users could publish their own services to others in social way.

The introduction of social relationship in our work is no longer only for sharing devices or data. We aim to structure an integrated social network, which is not dependent on the recent human social networks but a brand new ecosystem. In this paper, we first propose a framework of Social Web of Things, which is based on WoT architecture and introduce the concept of social network. We use supernetwork theory to illustrate the integrated structure of SWoT and discuss the service discovery model in our framework. As last, we introduced a SWoT prototype named MagicHome.

II. RELATED WORKS

Smart devices are widely deployed as the sensing elements to compose ubiquitous computing environments for the physical world. To meet the requirements of reuse and distribution of the resources and services of smart things, several systems have exposed the functionality of smart things upon which amount of applications could be built. SenseWeb [4] and Pachube [5] integrate the sensor systems with the Internet to form a centric platform where people share their sensory reading using web services. Furthermore, WoT (Web of Things) [1,2,3] for smart things interaction on application layer through web technologies on top of the network connected by IoT is proposed. The smart things in WoT can be easily accessed or controlled by users through open APIs as web services, and be composed to create new services.

The web enabled smart things to imply the possibility to integrate physical objects into web information

ecosystems seamlessly. Some applications take the social network as the mediation of data sharing between things or peoples. Dominique [7] proposed an access control framework of smart things depending on the structure of social networks. The friends or relatives of the sensor owner would share smart things without the need to recreate another user database for trust purpose. SenseShare [8] exploited social networks and structures to provide authentication, privacy, and security while sharing sensor data with other people.

[12-14] have discussed the Social Internet of Things concept, and have proposed the general SIoT structure. However, these prior works often focus on the social relationships between devices. The role of human is not considered in the previous work.

In addition to leveraging social community structure for secure distribution of smart things, smart things could play more significant roles in the social networks, and even behave as almost the same as human user do. They would have identical social user IDs through which people and other devices could be linked together. They can keep up to date with which device is doing what where. Mats Alendal [16] described a vision of social web of things. The things will have friends, post messages, follow news feeds, and even chat with other things and/or friends.

However, there isn't comprehensive understanding of the architecture for the social web of things as well as the technology challenges to implement the vision into reality. To facilitate the socialization of smart things in the web ecosystem, the design considerations of social web of things is proposed on which new capabilities could be easily envisioned.

III. THE FRAMEWORK OF SOCIAL WEB OF THINGS

The purpose of this paper is to present a framework for hybrid entities and complex relations in SWoT, and propose solutions to a number of issues that hinder implementation. The classical social network model has been adapted to handle the objects with minor changes [17], but it lacks a systematic and coherent theoretical basis, whereas an elegant unified theoretical basis already exists in the form of supernetwork modeling [18].

The supernetwork approach has been investigated and reported in [19] for a study area in The Netherlands (the Dordrecht-Rotterdam corridor) from a point of view of computational feasibility, the results of which were positive. Supernetwork, which consists of nodes, links (which may be physical virtual and, hence, are necessarily abstract), as well as the associated flows, were originally proposed in the context of transportation networks. The supernetwork models are usually adopted in the supply chain with electronic commerce, financial networks with intermediation, as well as telecommunication decision-making. [15]

In this section, we use supernetwork theory for simultaneously modeling the relationship of human, things, and services. For simplicity, we use things to denote sensors, actuators, and other electrical equipment etc. Also, human

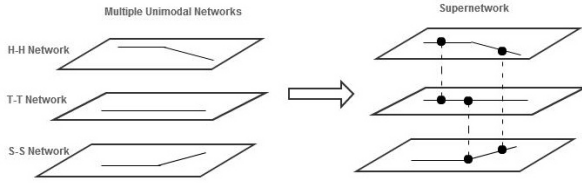


Figure 2. The Supernetwork Framework for SWoT

include the owner of things, service developer and service user.

As mentioned above, the entities participating in S-WoT could be divided into three types: human(owner of things, service developer and service user), things(such as devices, sensors, actuators)and services. Things could supply abundant sensing data and/or capabilities. Human could composite these various data and capabilities to services. Considering the importance of service in SWoT, we abstract services as nodes in our SWoT.

SWoT contains hybrid entities and complex relations between them. Therefore, in this paper we adopt supernetwork theory to describe the SWoT system. In the SWoT supernetwork (abbreviated for SWoTSN), the links corresponding to different relations, include, but not limited to: follower/friend links, co-owner links, co-work links and interface links, consolidation links, etc. Therefore , there exists three types of basic networks in SWoT

- Things-to-Things network (abbreviated as T-T network)is the social network between things in SWoT. The nodes are things and the links represent the relationship between things. Such as parental object relationship, co-location relationship, co-owner and co-work[12,13]. The T-T network could be modeled as $G_t=(T, E_{T-T})$, in which $T = \{t_1, t_2, \dots, t_b\}$ is the assembling of heterogeneous things in SWoT system, and $E_{T-T}=\{(t_i, t_j) | t_i, t_j \in T\}$ is the assembling of relations.
- Human-to-Human network (abbreviated as H-H network)is the social network between human in SWoT. The nodes are human and the links represent the relationship between them. Compared with recent human social network (facebook, twitter etc.), the relation types in the recent social network are often friends relationship, like the follower in Twitter. Although [14] has discussed the interests relationship model in human social network by supernetwork theory, the relations and nodes are far more complex in SWoT. We represent the H-H network as $G_h=(H, E_{H-H})$, in which $H = \{h_1, h_2, \dots, h_n\}$ is the assembling of human in the network, and $E_{H-H}=\{(h_i, h_j) | h_i, h_j \in H\}$ stands for the assembling of relations between human.
- Service-to-Service network (abbreviated as S-S network). From the discuss above, not only raw data and capabilities could be utilized as resourcesbut services could be published and utilized as resources as well. Meanwhile, different services could also access or

cooperate with each other. Therefore, we abstract service as nodes in the network. The network consists of services and could be represented as $G_s=(S, E_{S-S})$, in which $S = \{s_1, s_2, \dots, s_a\}$ is the assembling of services and $E_{S-S}=\{(s_i, s_j) | s_i, s_j \in S\}$ is the assembling of service cooperation relations.

To combine the three basic networks in our SWoT system, we introduce the mapping between each of them. Human-to-Things mapping relations, which we abbreviate as H-T. This kind of relation stands for the user who has things, and the thing belongs to whom. Things-to-Service mapping relations, which we abbreviate as T-S. This kind of relation stands for the service which has used data and capacity from which things, and the thing which has been accessed by which services. Human-to-Service mapping relations, which we abbreviate as H-S. This kind of relation stands for the user who has developed or used which services, and the service which has been accessed by whom.

Based on the mapping relations, we could integrate the networks G_h, G_t and G_s into a supernetwork by adding the mapping relations to the basic networks as links. In this paper, we call this network as SWoT supernetwork (SWoTSN). The processing as following:

Let each $h_i \in H$, $t_j \in T$ and $s_l \in S$ represents a certain node in the basic network separately. We use Boolean variable $\phi(h_i, t_j)$, $\phi(h_i, s_l)$ and $\phi(t_j, s_l)$ to represent the mapping relations between different types of nodes. The value of Boolean variable equals to 1 when there exists a relation between the two nodes. Else the value is 0. Therefore the SWoT could be modeled by supernetwork as

$$SWoTSN=f(G_h, G_t, G_s) = G_h + G_t + G_s + E_{H-T} + E_{T-S} + E_{H-S} \quad (1)$$

The links between different types of nodes are represented as:

$$E_{H-T}=\{(h_i, t_j) | \phi(h_i, t_j)=1\} \quad (2)$$

$$E_{H-S}=\{(h_i, s_l) | \phi(h_i, s_l)=1\} \quad (3)$$

$$E_{T-S}=\{(t_j, s_l) | \phi(t_j, s_l)=1\} \quad (4)$$

From the SWoTSN model above, we could conclude that SWoTSN is the integration of three types of basic networks, which consists of three types of nodes and six types of links.

IV. THE SERVICE DISCOVERY MODEL IN SWoT

A main advantage of SWoT is the improvement of resource sharing and service discovery. In this section, we use service discovery in SWoT as an example to further describe the SWoT. We give two service discovery models of as following.

Let α, β, γ denote the individual preference of human, thing and service separately, which would affect the service discovery. Figure 3 shows the basic service

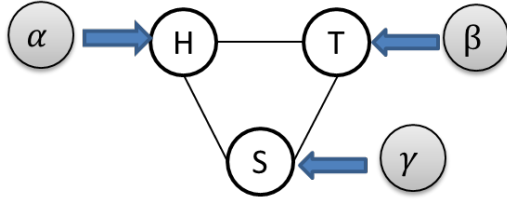


Figure 3. The Basic Service Discovery Model (BSDM)

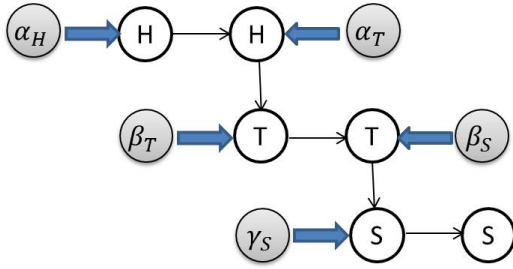


Figure 4. The Social Relation Based Service Discovery Model (SRSDM)

discovery model, in which only mapping relationships are considered.

For example, a developer wants to find a trusted temperature sensor. He can first choose the temperature relevant services he developed before. Then he can discover a temperature sensor, which is most-used in the services. Figure 4 shows the social relation based service discovery model, which introduce social relationships in the basic networks we discussed in section 3. This model is also the core of SWoT service discovery.

For example, a developer can discover a trusted temperature sensor not only by his evaluation but his friend's. Meanwhile, he could find more relevant sensors once he reached to the friend's sensor by the T-T relationships. Similarly, the developer could find more relevant services have been developed by him or his friends. We use SRSDM as an example to further describe the generation of service discovery in SWoT.

Let $H = \{h_1, \dots, h_n\}$ and $T = \{t_1, \dots, t_b\}$ denotes the sets of human and things in the network and $X = \{x_1, \dots, x_m\}$ denotes the set of directed links. Let p denote a service discovery path, assumed to be acyclic, and consist of a sequence of links connecting an origin/destination (O/D) pair of nodes. A link in the SWoTSN framework needs not correspond to a physical link, but may be abstract and associated with a factor of production or activity required for interaction.

(1) Path Representation

A path p could be divided into steps by the different character of nodes. Let $p_H(h^O, h_k) \in p, (k \in n)$ denote the sub-path on H-H network, and $p_T(t_l, t^D) \in p, (l \in b)$ denote the sub-path on T-T network, in which h^O and t^D stand for the origin node in H-H network and destination node in T-T network separately. Also, we let $x(h_k, t_l) \in p, (k \in n, l \in b)$ denote the link of p on H-T. So the path

p could be represented as:

$$p = \{p_H(h^O, h_k), p_T(t_l, t^D), x(h_k, t_l) | k \in n, l \in b\} \quad (5)$$

(2) Individual Preference

In traditional SNS, users have different preference in interaction, such as relation establishment and service acquisition. Therefore, we should consider the individual preference in SWoT. Similar to human's preference, heterogeneous things and various services in SWoT have different functions, characters and requirements. For example, a real-time service would prefer to employ the sensors have high sensitivity and another data mining service would better adopt sensors with high accuracy. Therefore, we also take the individual preference of things into account.

Let $\alpha_i = \{\alpha_{Hi}, \alpha_{Ti}, \alpha_{Si}\}, i \in n$ be the preference of user i to other users, things and services separately. Correspondingly, we adopt $\beta_j = \{\beta_{Hj}, \beta_{Tj}, \beta_{Sj}\}, j \in b$ and $\gamma_m = \{\gamma_{Hm}, \gamma_{Tm}, \gamma_{Sm}\}, m \in a$ to represent the preference of thing and service.

(3) Decision-Making

There are multiple relations between nodes in SWoTSN. This means that different nodes may play various roles in service discovery. So we need dynamic decision-making in generating service discovery path, which means when selecting a node in the path, we should consider the status of the previous node as well as the decision function.

Let $s(h_i)$ denote the status of h_i and $u_H(\cdot)$ denote the decision variable of the sub-path p_H . Considering the individual preference in path choice, $u_H(\cdot)$ could be reconstructed as $u_H = \{u_{H1}, u_{H2}, \dots, u_{Hn}\}$ and each $u_{Hi} \propto \alpha_i$. Similarly, we have the decision function u_T and u_S . Thus, the policy in a service discovery path could be represented as $U = \{u_H, u_T, u_S\}$.

(4) A Specific Multi-Objective Optimization Problem

We use the indicator function $v_i(s(h_i), u_{Hi})$ to represent the quality of the growth path. And we adopt $f(h^O, t^D)$ as the optimal indicator function in the from the origin node, so we have

$$f(h^O, t^D) = \text{opt}_{x(h_k, t_l)=1} \{f_H(h^O, h_k) + f_T(t_l, t^O)\} \quad (6)$$

$$f_H(h^O, h_k) = \text{opt} \left\{ \prod_{i=O}^k v_i(s(h_i), u_{Hi}) \right\} \quad (7)$$

$$f_T(t_l, t^O) = \text{opt} \left\{ \prod_{j=1}^D v_j(s(t_j), u_{Tj}) \right\} \quad (8)$$

in which $x(h_k, t_l) = 1$ means there is a link between h_k and t_l , and opt represents the optimal decision.

V. PROTOTYPE AND CASE STUDY

We deploy a typical SWoT scene called MagicHome to test the design of SWoT and demonstrate its feasibility.

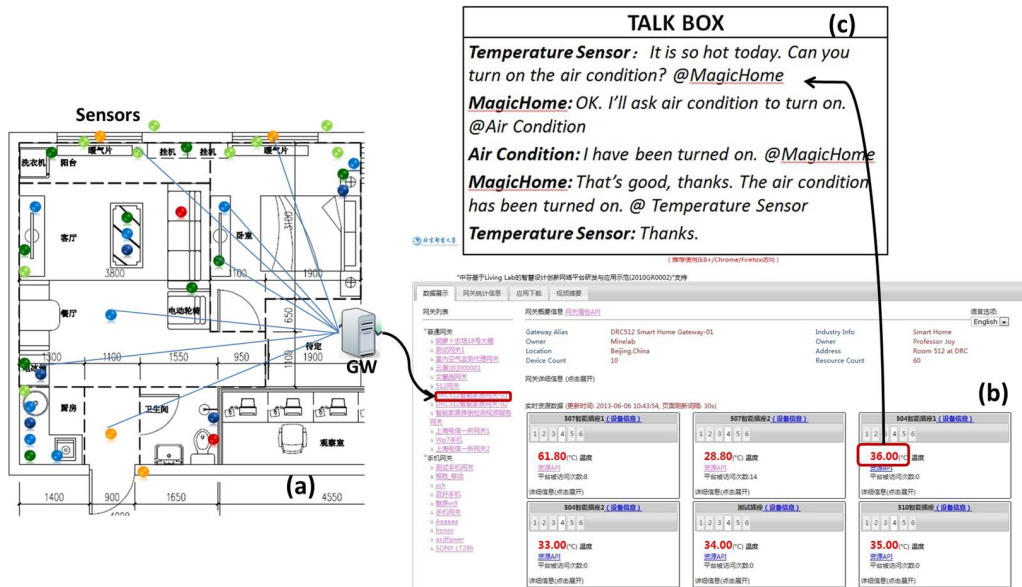


Figure 5. MagicHome Overview

A. MagicHome Overview

Figure 5(a) is the actual layout of MagicHome. It has a balcony, a living room, a bedroom, a dining room and a bathroom.

In MagicHome, there are lights, curtains, air conditioner, temperature and humidity sensor, luminance sensor, wind sensor, smoke sensor and other physical devices. Currently, these devices are connected wirelessly or wired to the smart gateway which acts as a broker to provide uniform web API for these devices.

The data are also collected and displayed on web pages (see figure 5(b)) <http://www.cloudsensing.cn:8080/>. MagicHome system provides the ability to customize rule configuration through web pages at <http://www.cloudsensing.cn:8199/>. Rule configuration XML file could be used by systems to handle different service discovery situations and the acquired data from APIs is used to trigger the rules. Based on the open APIs, human could upload their own devices and develop kinds of sensor based applications. Also, the system can achieve and save the social data, which we have discussed in section 2. Figure 5(c) is an example of the device chat scenario of MagicHome based on weibo.com, which is the biggest SNS website in China.

Till now, MagicHome only can support simple communication between human and things, which could be developed to test our SWoT framework and service discovery model in the future.

B. MagicHome System Description

As we introduced above, the main function of MagicHome system is to support a unified intelligent interaction between human and things. It means MagicHome system could collect data from heterogeneous devices, which we named WoT resource, and push the data to the social network as a human-friendly semantic format.

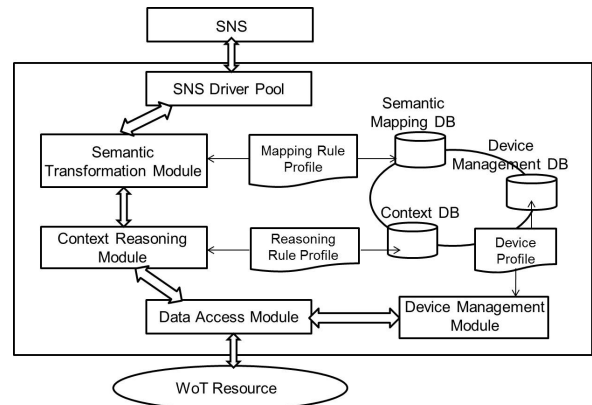


Figure 6. MagicHome System

Meanwhile, MagicHome system should also issue human comments to devices in machine language from social networks. Figure 6 demonstrates the main modules in MagicHome system, which includes Data Access Module, Context Reasoning Module, Semantic Transformation Module and SNS Driver Pool. Corresponding to figure 1 in section 1, these modules should be on the SWoT platform layer.

(1) Data Access Module

The Data Access Module is primarily responsible to collect data from the WoT resources such as sensors and to issue the messages and commands originated from SNS to WoT resources.

As mentioned before, the data and operation of WoT Resource has been abstracted into URLs by Restful Web Service and thus can be accessed or controlled through HTTP API. With respect to the discovery of such URLs, the Device Management Module can manage and provide device profile including the URL of each WoT Resource.

(2) Context Reasoning Module

In MagicHome system, the concept of Scenario is defined as a situation that some preset conditions are true. For example, we can define the scenario 'a room is hot' when the value of temperature is higher than 30C. Moreover, the scenario itself can be one of the conditions of a more complex scenario.

Upon receiving the data forwarded by Data Access Module, the Context Reasoning Module starts to reason whether a certain scenario is triggered and generate the metadata that annotate such scenarios, which could be essential to mapping semantic description in the Semantic Transformation Module.

(3) Semantic Transformation Module

In order to make the annotation of scenario understandable by human, the annotation of scenario has to be transformed into nature language. The process of transformation can be divided into two steps: 1) Build the semantic corpus. The corpus contains elementary nature language material that can be composed into nature language to describe the scenario in the next step. 2) Choose mapping algorithm to generate nature language with existing elementary materials. Here we just propose a framework to implement the semantic mapping. The algorithm can be chosen according to specific requirement case by case. Meanwhile, the algorithm can be also used to transform the messages and commands distributed from Social Network.

(4) SNS Driver Pool

The Social Network Service Driver Pool is the interface between the MagicHome server and social network web sites. By loading the SNS driver dynamically, the devices would have registered on any public or private social network and communicated with each other and human users in a social way. Also, devices could make friends with human users and receive commands from human.

C. The Design of MagicHome APIs

Each device or human could be regarded as a SWoT node. To enable the intelligent interaction between SWoT nodes, we need to design SWoT APIs. Although the existing SNS APIs provide a well foundation for SWOT platform, we still need to improve a part of SNS APIs in order to adapt to the SWoT environment.

The design of SWoT APIs in our MagicHome prototype is given below. There exists several APIs in our MagicHome prototype, such as user info APIs and control APIs. With these APIs, we can register sensors and services on the MagicHome platform, and search/recommend devices or services by their social relations or key-values.

(1) User Info APIs

User info APIs are consisted of user info write API, read API and search API. With these APIs, individuals and applications can write in or get user profile and social information which includes human users' name, gender, age, etc. and device users' name, type, function, location, output, units, etc.. The writable content includes key-value and social relation.

Example (user info write API):
 API URL: `https://api.SWOT.com/user_info/write`
 HTTP Request Method: POST
 Request Parameter: id or name, key-value, social relation
 Request:
 POST `https://api.SWOT.com/user_info/write?name=air condition& key-value= location -Beijing Room512 & key-value = type -household appliances& social relation= friend-temperature sensor`
 Result: 200

Returned 200 shows that we have successfully written in the air condition's Info which including location, type, function and social relation.

User also can search based on the above user information. With search API, we can search devices or services by their social relations or key-values instead of the only name and we will get more accurate search results. Also, we can acquire different user info based on the needs of various search requirements. The parameter 'count' is to limit the number of results returned.

Example (user info search API) :
 API URL: `https://api.SWOT.com/user_info/search`
 HTTP Request Method: GET
 Request Parameter: key-values, count, social relations
 Request:
 GET `https://api.SWOT.com/user_info/search?key-value= type-household appliances & key-value=location-BUPT& social relation= friend-temperature sensor & count=10`

(2) Control APIs

Control APIs contain device status read API and device status write API. With this API, individuals can acquire real-time device status and permitted individuals can control the devices, such as turn on and turn up.

Example (device status read API):
 API URL: `https://api.SWOT.com/control/read`
 HTTP Request Method: GET
 Request Parameter: id or name, type
 Request:
 GET `https://api.SWOT.com/control/read?name=air condition& type= switch`

The parameter 'type' represents a type of device status. For example, air condition has two statuses which are switch and amplitude.

Example (device status write API):
 API URL: `https://api.SWOT.com/control/write`
 HTTP Request Method: POST

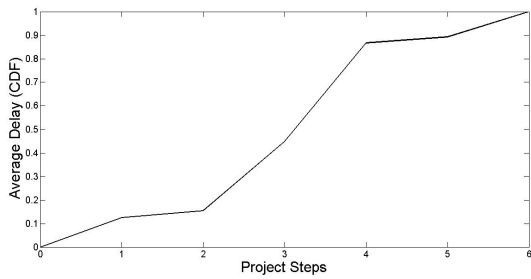


Figure 7. Real-time Performance of SWoT System

```
Request Parameter: id or name, type,
operation
Request:
POST https://api.SWoT.com/control/
write?name=air condition& type= switch
& operation= turn on
Result: 200
```

D. MagicHome API Evaluation

In this section, we will test the real-time performance of SWoT system by means of the MagicHome. Then we will compare it with real-time performance of a pure IoT system.

(1) The Project of Context Reasoning

The project is similar to figure 5(c), which is a device chat scenario of MagicHome based on weibo.com.

a) For temperature sensor

IF the value of temperature sensor is greater than 28 degrees,

THEN temperature sensor @air condition: so hot, temperature down.

b) For air condition

IF receive @message: temperature down,
THEN turn on air condition and refrigeration.

(2) MagicHome Real-time Performance

Since this project based on weibo.com, and the IoT API and weibo API does not use push mechanism, we use high frequency polling (100 times per second) to get real-time information. Figure 7 shows the result.

Step 1: from 'temperature sensor value = 28' to 'MagicHome platform get temperature data'

The average delay of performing 10 times is 35 ms, mainly spent on the IoT APIs polling and IoT API perform. The number of API calls and polling interval time can be effectively reduced if we use push mechanism API instead of polling.

Step 2: to 'MagicHome platform output the result of context reasoning'

The average delay of performing 10 times is 7 ms, which mainly spent on database query of context reasoning and platform internal execution.

Step 3: to 'weibo.com show @micro-blog'

The average delay of performing 10 times is 82 ms, mainly spent on SNS API perform.

Step 4: to 'MagicHome platform get @micro-blog'

The average delay of performing 10 times is 117 ms, mainly spent on the SNS APIs polling and SNS API perform.

Step 5: to 'MagicHome platform output the result of context reasoning'

The average delay of performing 10 times is 7 ms, mainly spent on database query of context reasoning and platform internal execution.

Step 6: to 'turn on air condition'

The average delay of performing 10 times is 30 ms, mainly spent on IoT API perform.

(3) IoT real-time performance

We evaluated the real-time performance of the terminals with an IoT system and two different IoT systems respectively.

a) When two terminals are in an IoT system

Terminal interaction is the information exchanged within the system. Delay is generated by the platform invoking terminal APIs and platform internal processing. After testing, the system delay like the step 1, 2, 6 of SWoT system.

b) When two terminals are in different IoT systems

The system delay also includes information exchange between different platforms. In this case, the real-time performance is similar to the SWoT system that the system delay is mainly produced by the communication mechanisms and is occurred between the different platforms

VI. CONCLUSION

In this paper, we first introduced our perspective over SWoT and then proposed a SWoTSN model for structuring an integrated social network between human and things. This framework facilitates the socialization of smart things and services in the web ecosystem. We also discussed the service discovery model on the SWoTSN, which is a specific multi-objective optimization problem. At last, we gave the MagicHome prototype.

However, user experience of social interaction between human and physical devices in SWoT still needs further test. Meanwhile, the advanced APIs should be developed, such as the service discovery API. This will be part of our future work. In addition, research deeply on technologies of resource discovery, semantic interpreter, context modeling and privacy etc. in the new environment are still necessary.

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